Evans Creek Watershed Hydrologic Study

Michigan's Nonpoint Source Program

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March 17, 2005

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The Evans Creek hydrologic study was funded by a Part 319 grant from the
United States Environmental Protection Agency to MDEQ's Nonpoint Source program.
For more information, go to www.michigan.gov/deqnonpointsourcepollution.

Summary

A hydrologic model of the Evans Creek watershed was developed by the Hydrologic Studies Unit (HSU) of the Michigan Department of Environmental Quality (MDEQ) using the Hydrologic Engineering Center's Hydrologic Modeling System (HEC-HMS). The hydrologic model was developed to help determine the effect of land use changes on the Evans Creek's flow regime and to provide design flows for streambank stabilization Best Management Practices (BMPs). Watershed stakeholders may combine this information with other determinants, such as open space preservation, to decide what locations are the most appropriate for wetland restoration, stormwater detention, in-stream BMPs, or upland BMPs. Local governments within the watershed could also use the information to help develop stormwater ordinances.

The hydrologic model has three scenarios corresponding to land uses in 1800, 1978, and 1998. General land use trends are illustrated in Figure 1. More detailed land use information is provided in Table 1 in the Watershed Description and Model Parameters section of this report.

The model shows increases in stormwater runoff volumes and peak flows from 1800 to 1978, but little change from 1978 to 1998, for the 50 percent chance (2-year) and 4 percent chance (25-year) 24-hour design storms. The increases are due to changes in land use and loss of storage. Overall results are illustrated in Figures 10 through 13. Detailed data and discussion of the results are in the Model Results section of this report.

Increases in the runoff volume and peak flow from the 4 percent chance, 24-hour storm could cause or aggravate flooding problems unless mitigated using effective stormwater management techniques. Increases in the 50 percent chance, 24-hour storm will increase channel-forming flows. The channel-forming flow in a stable stream usually has a one- to two-year recurrence interval. These relatively modest storm flows, because of their higher frequency, have more effect on channel form than extreme flood flows. Hydrologic changes that increase this flow can cause the stream channel to become unstable. Stream instability is indicated by excessive erosion at many locations throughout a stream reach. Stormwater management techniques used to mitigate flooding can also help mitigate projected channel-forming flow increases. However, channel-forming flow criteria should be specifically considered in the stormwater management plan so that the selected BMPs will be most effective. For example, detention ponds designed to control runoff from the 4 percent chance, 24-hour storm may do little to control the runoff from the 50 percent chance, 24-hour storm, unless the outlet is specifically designed to do so.

One way to compare runoff from different subbasins or watersheds is to calculate the yield, which is the peak flow divided by the drainage area. The area-weighted average yield from the 50 percent chance (2-year), 24-hour storm for the Evans Creek watershed is 0.03 cubic feet per second per acre (cfs/acre) for 1978 and 1998 land use scenarios. This value may be used to guide stakeholders' stream stability management

decisions. The area-weighted average yield from the 4 percent chance (25-year), 24-hour storm for the Evans Creek watershed is 0.09 cfs/acre for 1978 and 1998 land use scenario. This value may be used to guide stakeholders' flood control management decisions. Additional details are shown in Figures 14 and 15 and in the Model Results section of this report.

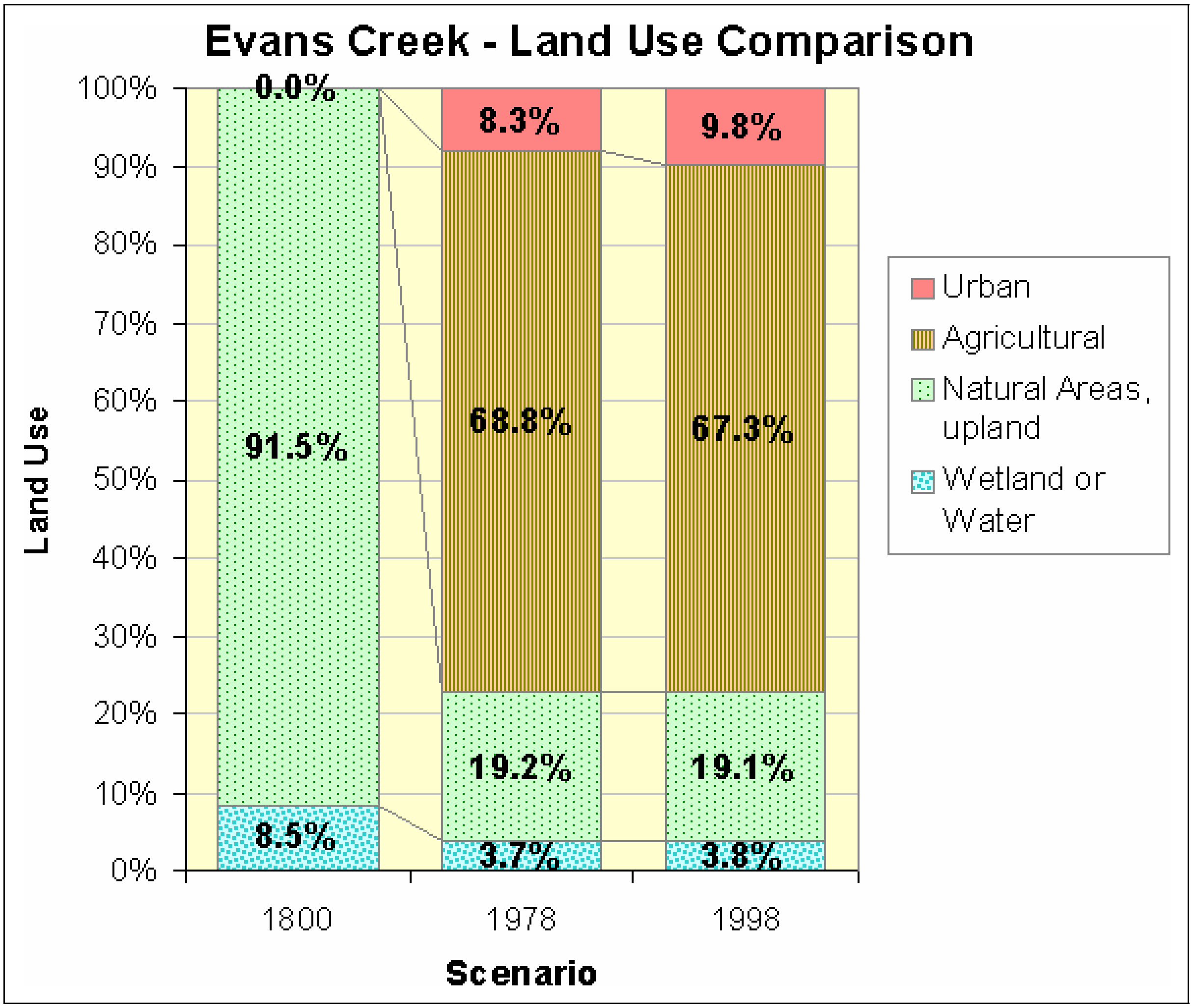

Figure 1: Land Use Comparison

Project Goals

The Evans Creek hydrologic study was initiated in support of the River Raisin Watershed Council (RRWC), which is developing a watershed management plan for the River Raisin watershed. Evans Creek was identified by RRWC as one of several key watersheds within the larger River Raisin watershed that have multiple nonpoint source pollution problems, including numerous reports of streambank erosion sites and high nutrient loading. The watershed also has active local stakeholders working to address the problems. This Evans Creek hydrologic study is funded by a United States Environmental Protection Agency (USEPA) Part 319 grant administered by the MDEQ. The goals of this Evans Creek study, and the broader River Raisin watershed plan, are:

- To better understand the watershed's hydrologic characteristics and the impact of hydrologic changes in the Evans Creek watershed
- To facilitate the selection and design of suitable BMPs
- To provide information that can be used by local units of government to develop or improve stormwater ordinances
- To help determine the watershed management plan's critical areas – the geographic portions of the watershed contributing the majority of the pollutants and having significant impacts on the waterbody

Watershed Description and Model Parameters

The 33 square mile Evans Creek watershed (Figure 2) outlets to the River Raisin at Tecumseh and is located in Lenawee and Washtenaw counties. In this study, the Evans Creek watershed was delineated to its inlet at Globe Mill pond, a combined impoundment at the confluence of Evans Creek with the River Raisin. This Evans Creek study divides the watershed into seven subbasins, as shown in Figure 3.

Some areas of the watershed are defined as non-contributing, meaning they do not contribute surface runoff during flood events. One such area is the Evans Lake drainage area. Because the United States Geological Survey (USGS) topographic quadrangle shows Evans Lake approximately three feet lower than the outlet channel, we expect that the Evans Lake subbasin generally does not contribute surface runoff to Evans Creek. The reported results for the Evans Lake subbasin include only the runoff volumes, which would accumulate in the Evans Lake and increase its water surface elevation.

Evans Creek's profile, Figure 4, is somewhat unusual. A typical profile is steeper in the headwaters and flattens out toward the mouth. Based on the USGS quadrangle, Evans Creek appears to consist of three steeper reaches alternating with two flatter reaches.

Our analysis of the watershed uses the curve number technique to calculate surface runoff volumes and peak flows. This technique, developed by the Natural Resources Conservation Service (NRCS) in 1954, represents the runoff characteristics from the combination of land use and soil data as a runoff curve number. The technique, as adapted for Michigan, is described in "Computing Flood Discharges For Small Ungaged Watersheds (Sorrell, 2003), www.deq.state.mi.us/documents/deq-glm-water-scs2003.pdf.

The curve numbers for each subbasin, listed in Appendix A, were calculated using Geographic Information Systems (GIS) technology from the digital land use and soil data shown in Figures 5 through 9. Land use maps based on the MDEQ GIS data for 1800 and 1978 are shown in Figures 5 and 6, respectively. The 1800 land use information is provided at the request of the RRWC. The MDEQ Nonpoint Source program does not expect or recommend that the flow regime calculated from 1800 land use be used as criteria for BMP design or as a goal for watershed managers. The aerial photos in Figure 7 were used to estimate housing densities, which is needed to calculate the runoff curve numbers. Based on the aerial photos, an average residential lot size was assumed to be 1/3 acre for the Tecumseh and Evans Lake subbasins, EC1 and EC5 respectively, and 1/2 acre for all other subbasins. The 1998 land use map, Figure 8, is based on HSU's analysis of the 1998 aerial photos.

The aerial photography depicted in Figure 7 is a composite of ten 1998 false-color infrared aerial photos. In false-color infrared photos, bright red areas indicate vigorous plant growth. The brightest areas are usually yards and golf courses. Deciduous trees are various shades of dark gray because the photos are generally taken in April for leaf off conditions. Coniferous trees are dark red and are typically very compact when in plantations. Open fields with grasses, forbs, or shrubs are often pink or grayish mixed with pink because there is generally not a lot of vigorous growth when the photos are taken. Because plant coverage is generally minimal in agricultural fields, they are typically gray-green and often mottled-looking (light and dark areas). Water is often black or even bluish, depending on the sediment content in the water. The reflectivity of impervious areas varies and often appears either white or dark.

The NRCS soils data for the watershed is shown in Figure 9. Where the soil is given a dual classification, B/D for example, the soil type was selected based on land use. In these cases, the soil type is specified as D for natural land uses, or the alternate classification (A, B, or C) for developed land uses. The runoff curve numbers calculated from the soil and land use data are listed in Appendix A. The time of concentration for each subbasin, which is the time it takes for water to travel from the hydraulically most distant point in the watershed to the design point, was calculated from the USGS quadrangles. The storage coefficients, which represent storage in the subbasin, were iteratively adjusted to provide a peak flow reduction equal to the ponding adjustment factors detailed in Appendix A.

The reach routing method is the lag method. Lag is the travel time of water within each section of the stream. The method translates the flood hydrograph through the reach without attenuation. It is not appropriate for reaches that have ponds, lakes, wetlands, or flow restrictions that provide storage and attenuation of floodwater. Lag values for each reach were calculated using USGS quadrangles and are listed in Appendix A.

The selected precipitation events were the 50 and 4 percent chance (2- and 25-year), 24-hour storms. Design rainfall values for these events are tabulated in *Rainfall Frequency Atlas of the Midwest*, Bulletin 71, Midwestern Climate Center, 1992, pp. 126-129, and summarized for this site in Appendix A. These values have been multiplied by 0.96 to account for the size of the watershed.

These parameters were then incorporated into a HEC-HMS model to compute runoff volume and flow.

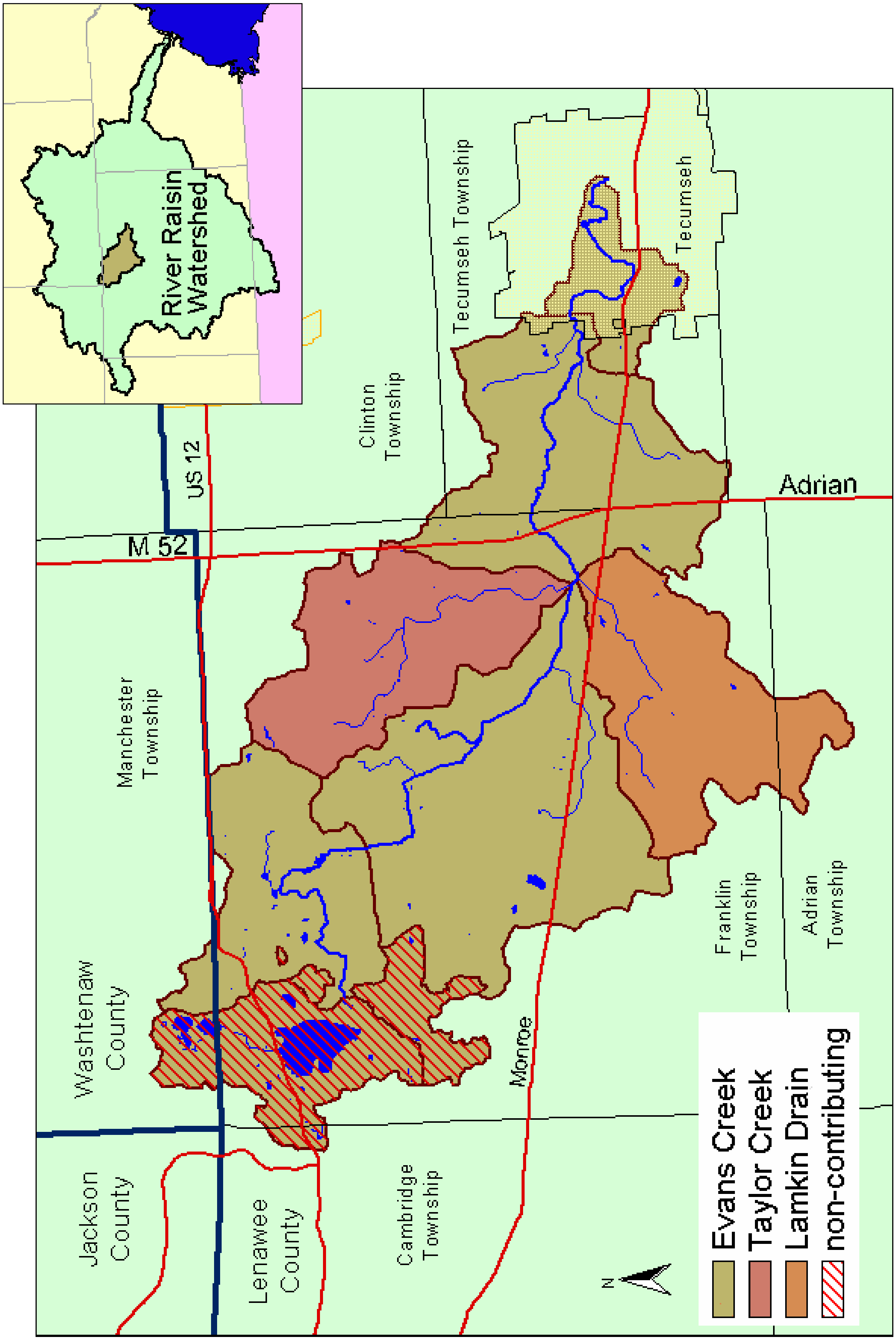

Figure 2: Delineated Evans Creek Watershed

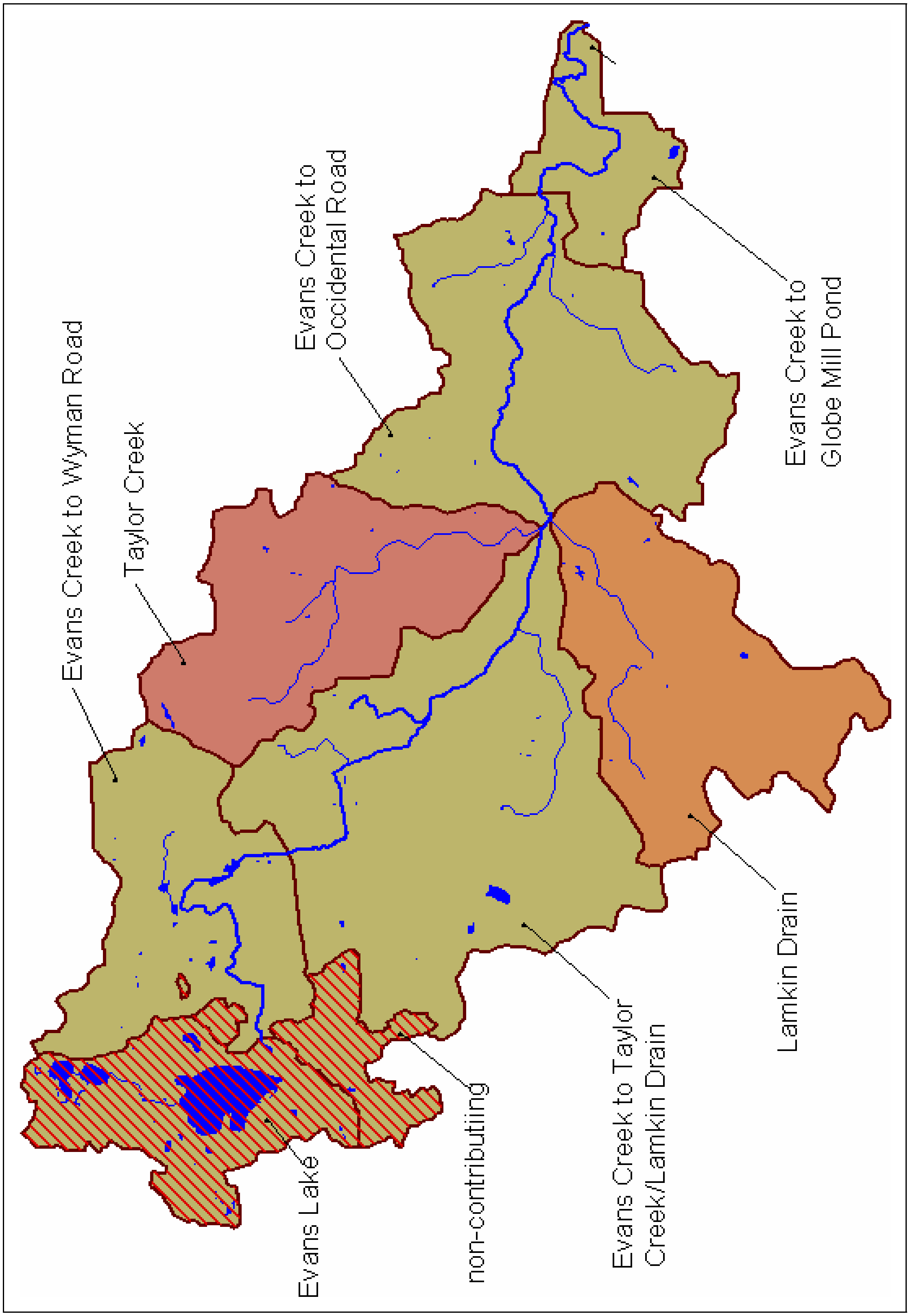

Figure 3: Subbasin Identification

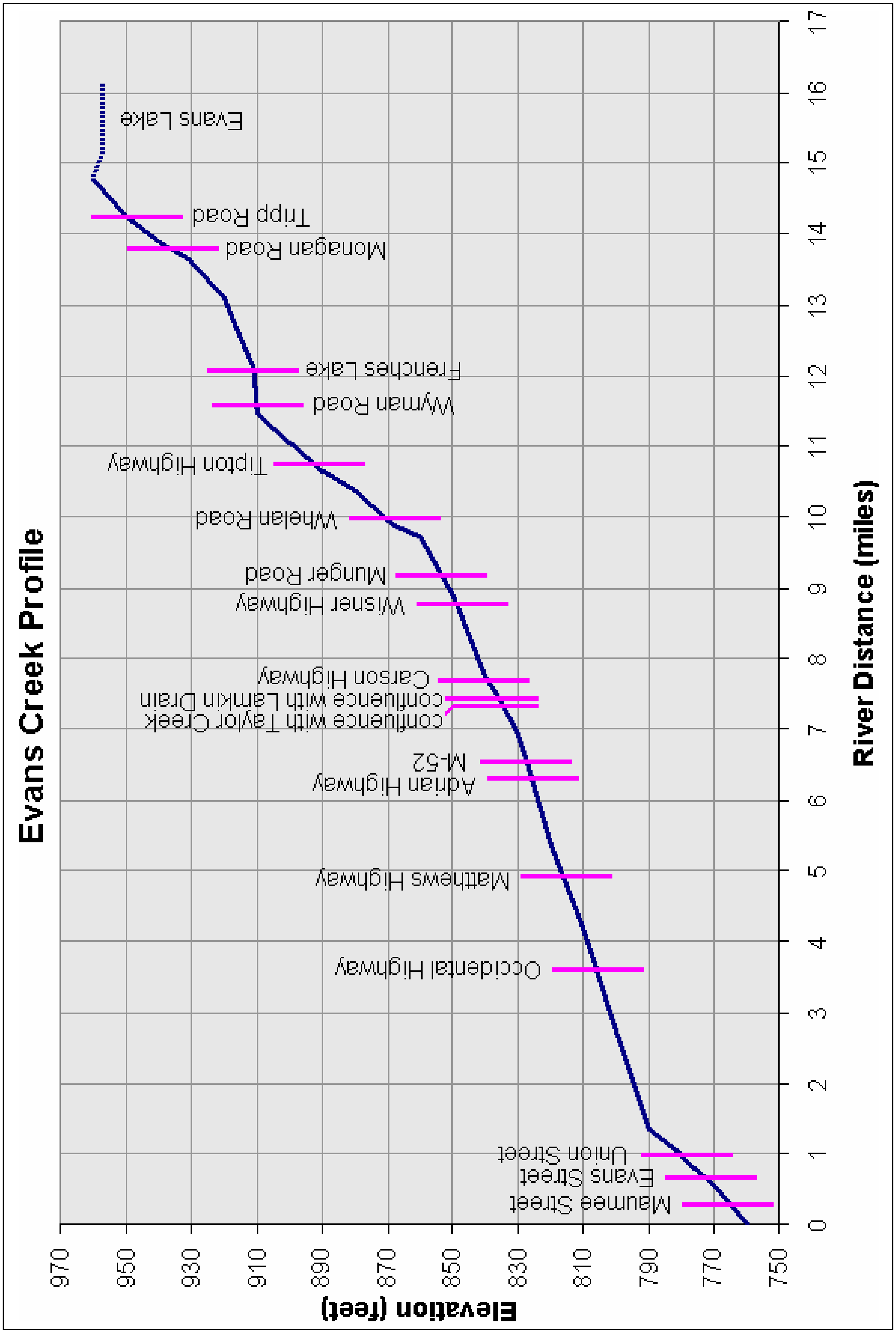

Figure 4: Evans Creek Profile

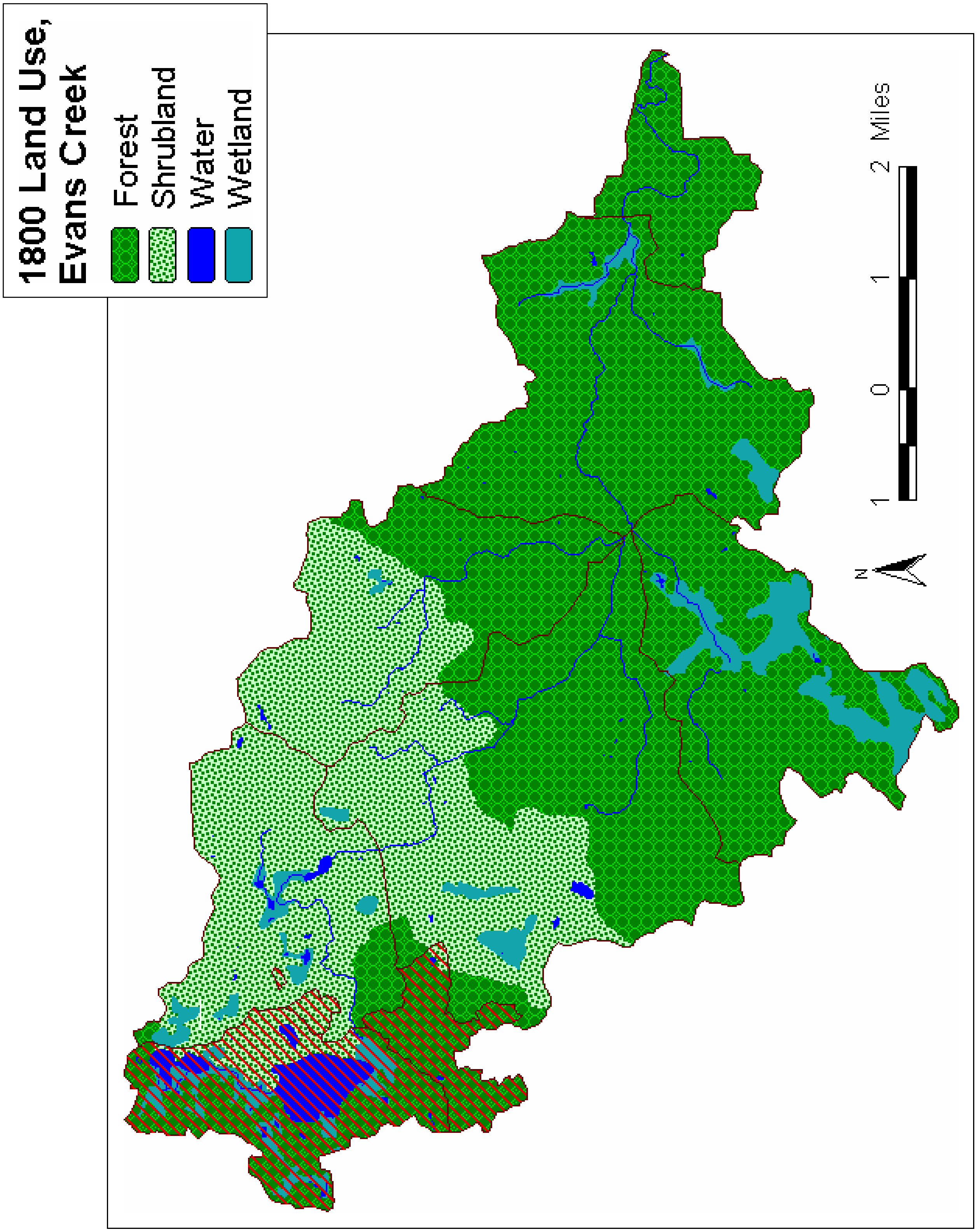

Figure 5: 1800 Land Use Data

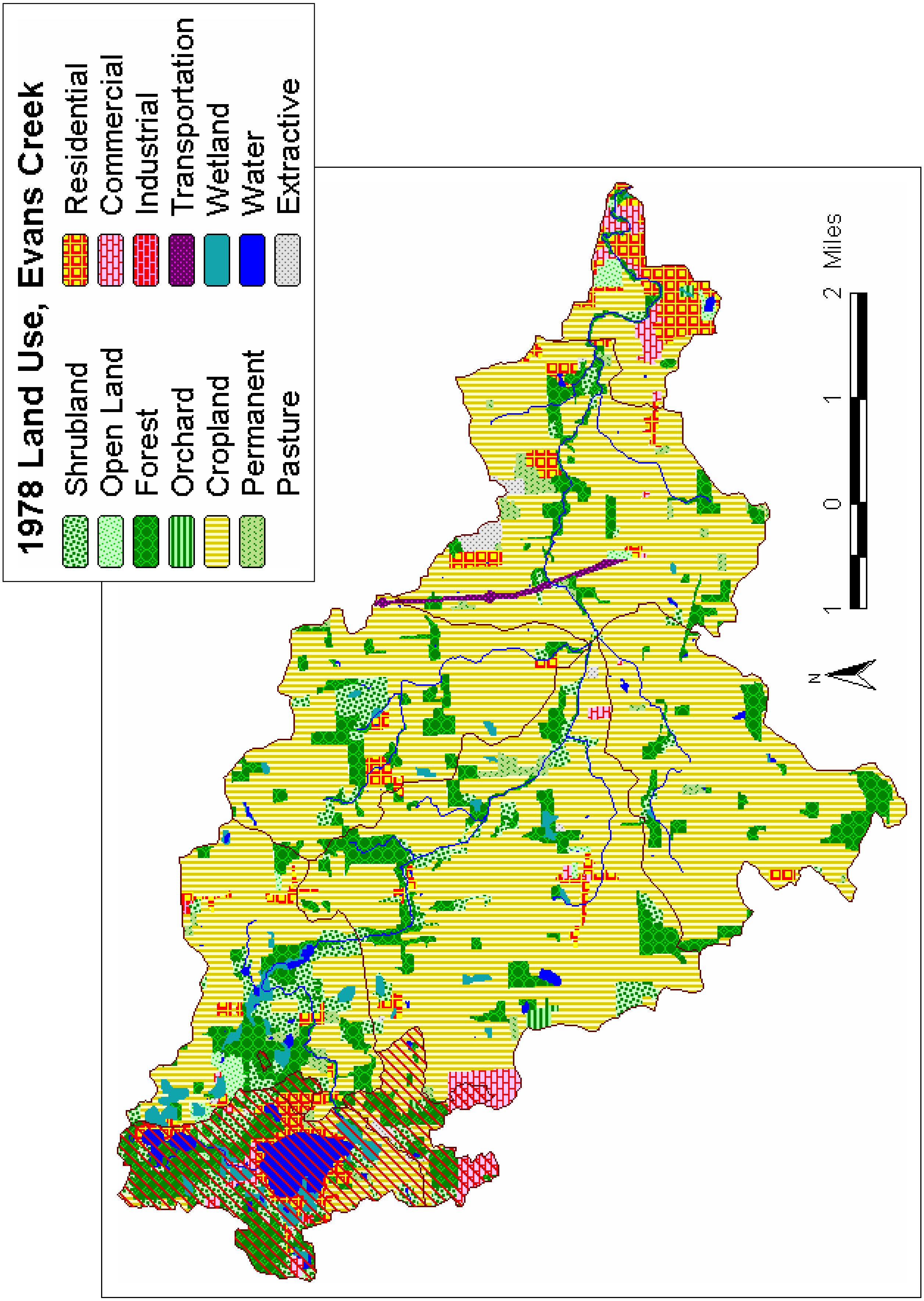

Figure 6: 1978 Land Use Data

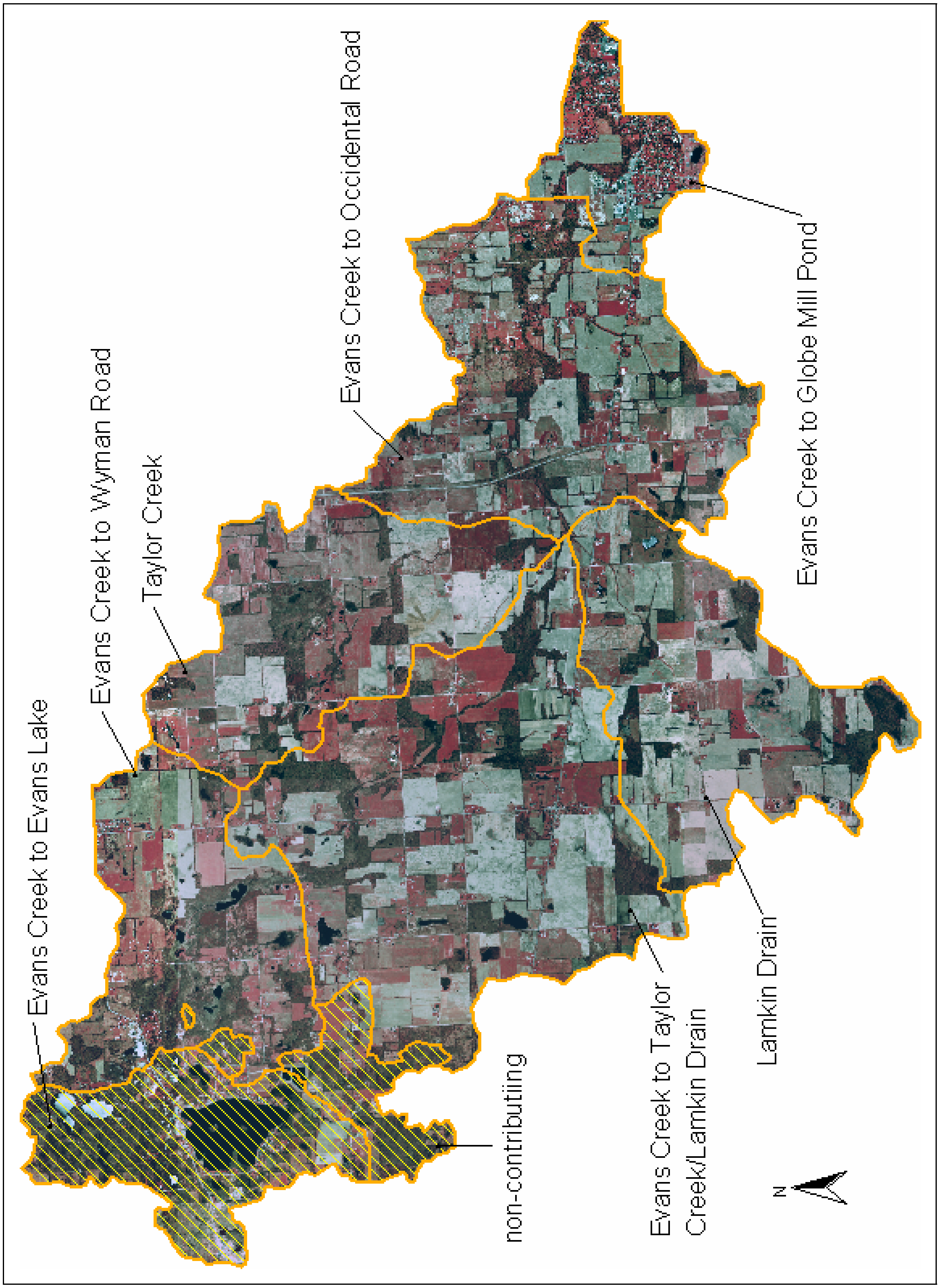

Figure 7: 1998 Aerial Photo

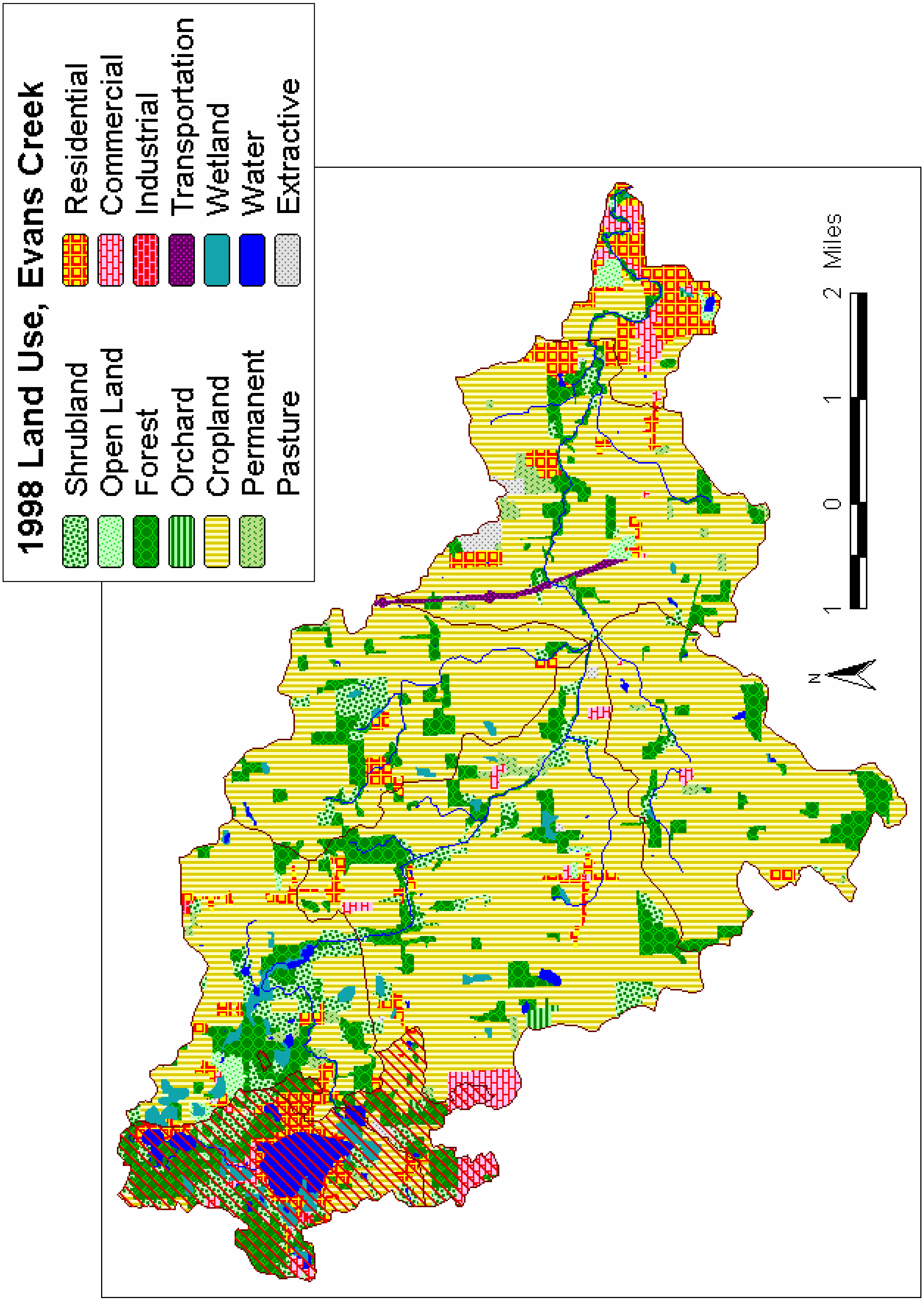

Figure 8: 1998 Land Use Data

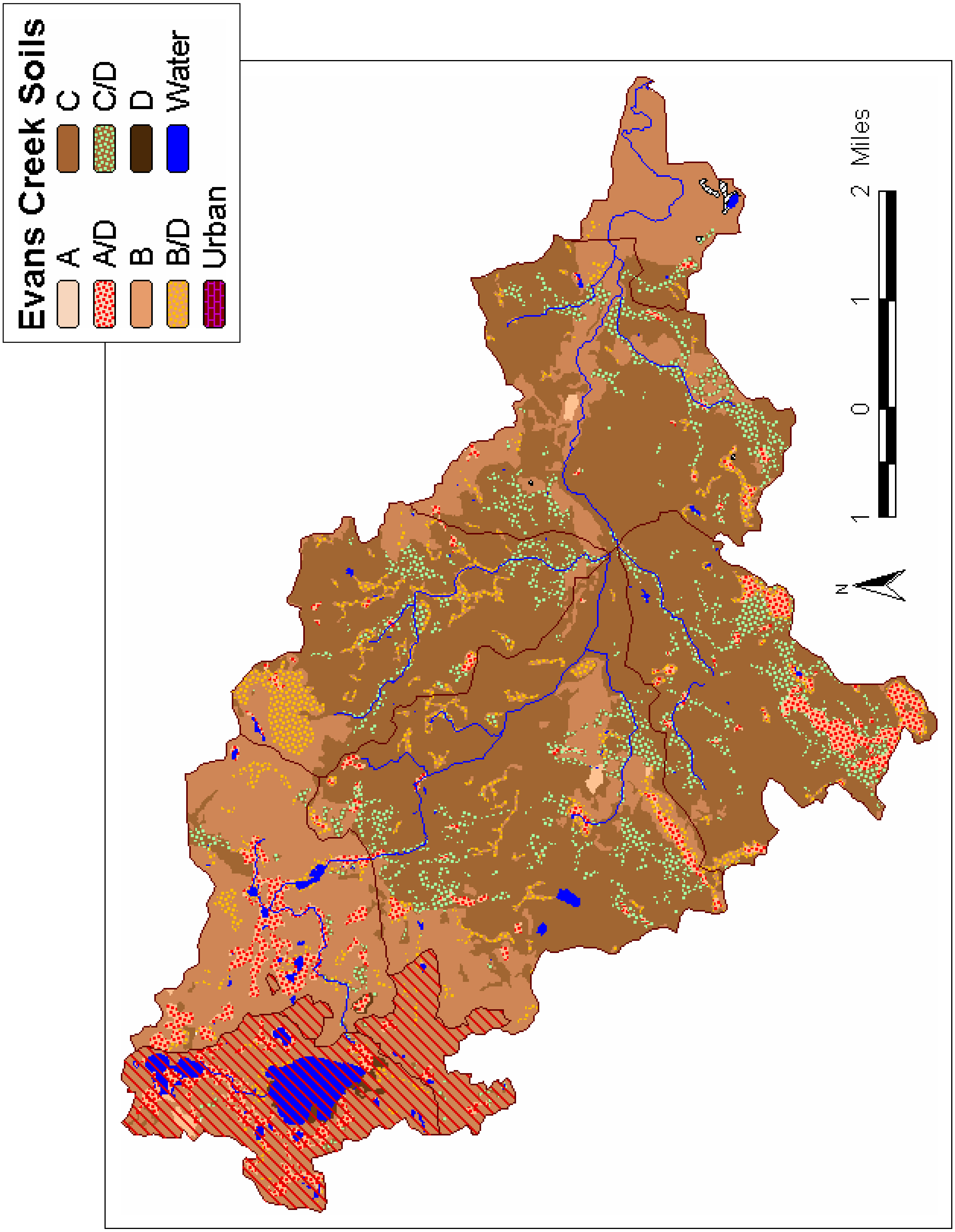

Figure 9: NRCS Soils Data

Table 1: Land Use by Subbasins (Land uses less than 0.5 percent are not listed because all percentages are rounded to the nearest percent)

Description	Scenario	Residential	Commercial	Utilities	Gravel Pit	Cemeteries, Outdoor Rec.	Cropland	Orchard	Pasture	Herbaceous Openland	Forest	Water	Wetland
EC1	1800										100%		
	1978	32%	14%			6%	37%	1%		1%	8%	1%	
	1998	37%	15%			6%	32%			1%	8%	1%	
EC2	1800										96%		4%
	1978	4%		2%	2%		76%		4%	1%	11%		
	1998	6%		2%	2%	1%	73%		3%	1%	11%		
EC3	1800									41%	57%		2%
	1978	2%	2%				75%	1%	1%	5%	12%		1%
	1998	3%	3%				74%	1%	1%	5%	12%		1%
EC4	1800									83%	8%	1%	8%
	1978	4%				3%	53%		2%	12%	17%	1%	7%
	1998	7%				3%	52%		2%	11%	17%	1%	7%
EC5	1800									17%	50%	17%	17%
	1978	11%	3%		1%	2%	14%		1%	16%	29%	15%	8%
	1998	12%	4%			2%	12%		1%	16%	29%	16%	8%
LD	1800										80%		20%
	1978	1%					85%		1%	1%	12%		
	1998	1%					85%		1%	1%	12%		
TC	1800									56%	43%		1%
	1978	3%					77%			5%	13%		1%
	1998	3%					77%			5%	13%		1%
Total	1800									31%	61%	2%	7%
	1978	5%	2%			1%	67%		2%	5%	14%	2%	2%
	1998	6%	2%			1%	66%		1%	5%	14%	2%	2%

Model Results

General Results

Model results are illustrated in Figures 10 through 20 and detailed in Tables 3 and 4. Table 3 lists the computed peak flows and runoff volumes from each subbasin. These values represent the peak flow contribution from the subbasins, not the flow in the river. Table 4 and Figures 10 through 13 show the computed peak flows and runoff volumes at locations in the river.

The increases in stormwater runoff volume and peak flows conditions from 1800 to 1978 are due to changes in land use and loss of storage. The hydrologic model shows significant increases in runoff volumes and peak flows for both design storms. Peak flows and runoff volumes from the 50 percent chance 24-hour storm are predicted to increase more, on a percentage basis, than flows from the 4 percent chance, 24-hour storm. Increases in runoff volumes and peak flows from the 50 percent chance storm increase channel-forming flows, which will increase streambank erosion as the stream enlarges to accommodate the higher flows. Channel-forming flow is the flow that is most effective at shaping the channel. In a stable stream, the channel-forming flow has a one- to two-year recurrence interval and is the bankfull flow. Increases in runoff volumes and peak flows from the 4 percent chance storm will aggravate flooding. These increases can be moderated through the use of effective stormwater management techniques. A stream can take 60 to 80 years or more to adapt to flow changes.

From 1978 to 1998, urban land uses increased 19 percent, with most of the development displacing agricultural land, as shown in Table 2. This represents the urbanization of 1.6 percent of the watershed during this period. The modeled runoff volumes and peak flows for this period remain essentially unchanged, primarily because the transition from farmland to low-density housing is, hydrologically, approximately equivalent, and the expected runoff volume is similar.

Table 2: General Land Use Trends

Land Use	1978 (acres)	1998 (acres)	Change(acres)	Change
Urban	2,014	1,695	320	19%
Agricultural	13,804	14,121	-317	-2%
Natural	4,701	4,705	-3	0%
Total	20,520	20,520		

Yield Analysis

One way to compare runoff from different subbasins or watersheds is to calculate the yield, which is the peak flow divided by the drainage area. Yields have also been used help select critical areas in a watershed plan and as a basis for stormwater management BMPs. A model stormwater ordinance adopted by Kent County, www.accesskent.com/YourGovernment/DrainCommisioner/drain_stormwater.htm, calls for a maximum release rate of 0.05 cfs/acre for runoff from the 50 percent chance, 24-hour storm for Zone A areas, the most environmentally sensitive of the three management zones. Currently, the area-weighted average yield from this storm for the Evans Creek Watershed is 0.03 cfs/acre, with no subbasin greater than 0.04 cfs/acre, as shown in Figure 14. The Kent County ordinance also calls for a maximum release rate of 0.13 cfs/acre for runoff from the 4 percent chance, 24-hour storm for Zones A and B. Currently, the area-weighted average yield from this storm is 0.09 cfs/acre, with no subbasin greater than 0.11 cfs/acre, as shown in Figure 15. Additional details are listed in Table 2. If the Evans Creek watershed stakeholders use the Kent County model ordinance as a model for an Evans Creek stormwater ordinance, they should consider whether the Kent County model ordinance standards will adequately protect Evans Creek and its tributaries.

Evans Creek and its tributaries are not classified as trout streams by Michigan's Department of Natural Resources. The results of this hydrologic study suggest that this is unlikely to change. In many of our other watershed studies, we have compared the flows from the 50 percent chance, 24-hour storm to flows based on a target yield of 0.0075 cfs/acre. This target yield was selected as criteria for a good trout fishery based on Mike Wiley and Paul Seelbach's November 1998 report titled "*An ecological assessment of opportunities for fisheries rehabilitation in the Pigeon River, Ottawa County*." Although clearly not the sole factor determining fish habitat quality, good quality trout habitat generally corresponds to the locations with yields less than the target yield. Impaired habitat generally corresponds to locations with yields less than about 1.4 times the target yield. Locations with higher yields generally do not have trout. These same thresholds, applied to the Evans Creek results, are shown in Figure 16. For the 1800 scenario, only Evans Creek at Wyman Road would be considered good. All other locations would be poor. For the 1978 and 1998 scenarios, all locations would be poor.

Peak Flow Timing Analysis

Evans Creek has two main tributaries, Taylor Creek and Lamkin Drain, that flow into Evans Creek within 600 feet of each other. In the Macatawa River watershed, a hydrologic study revealed that three tributaries peaked at about the same time (page 8, *A Hydrologic Study of the Macatawa River Watershed*, MDEQ's Hydrologic Studies Unit). A project to alter the timing of one of the three tributaries, and reduce downstream flooding, is in progress. In Evans Creek, the tributaries do not peak at the same time, as shown in Figures 17 and 18. Projects that reduce this timing differential have the potential to disproportionately increase peak flows in the main stem of the Evans Creek.

Runoff from Tecumseh enters the Evans Creek well ahead of the peak flow, as shown in Figures 19 and 20. Detention of the city's stormwater runoff will not noticeably change the flow regime of Evans Creek. This city's stormwater management plan should focus on treating the runoff to maintain water quality and providing sufficient drainage capacity to minimize flooding. Detention/retention BMPs might be encouraged or required for other reasons, such as water quality improvement, groundwater replenishment, or if hydrologic analysis of the River Raisin indicates, continued urbanization of the region would alter the flow regime of the river.

Evans Lake

Because the USGS topographic quadrangle shows Evans Lake approximately three feet lower than the outlet channel, the drainage area to Evans Lake was modeled as non-contributing, meaning it generally does not contribute surface runoff to Evans Creek. Table 3 only lists Evans Lake runoff volumes, which would accumulate in Evans Lake and increase its water surface elevation.

The surface area of Evans Lake is approximately 200 acres, with a total of just under 300 acres of lakes in the 1,800-acre drainage area. The maximum calculated runoff to Evans Lake from the four percent chance 24-hour storm is 190 acre-feet, as listed in Table 4. We therefore expect that runoff from the four percent chance 24-hour storm would raise the lake level by less than one foot.

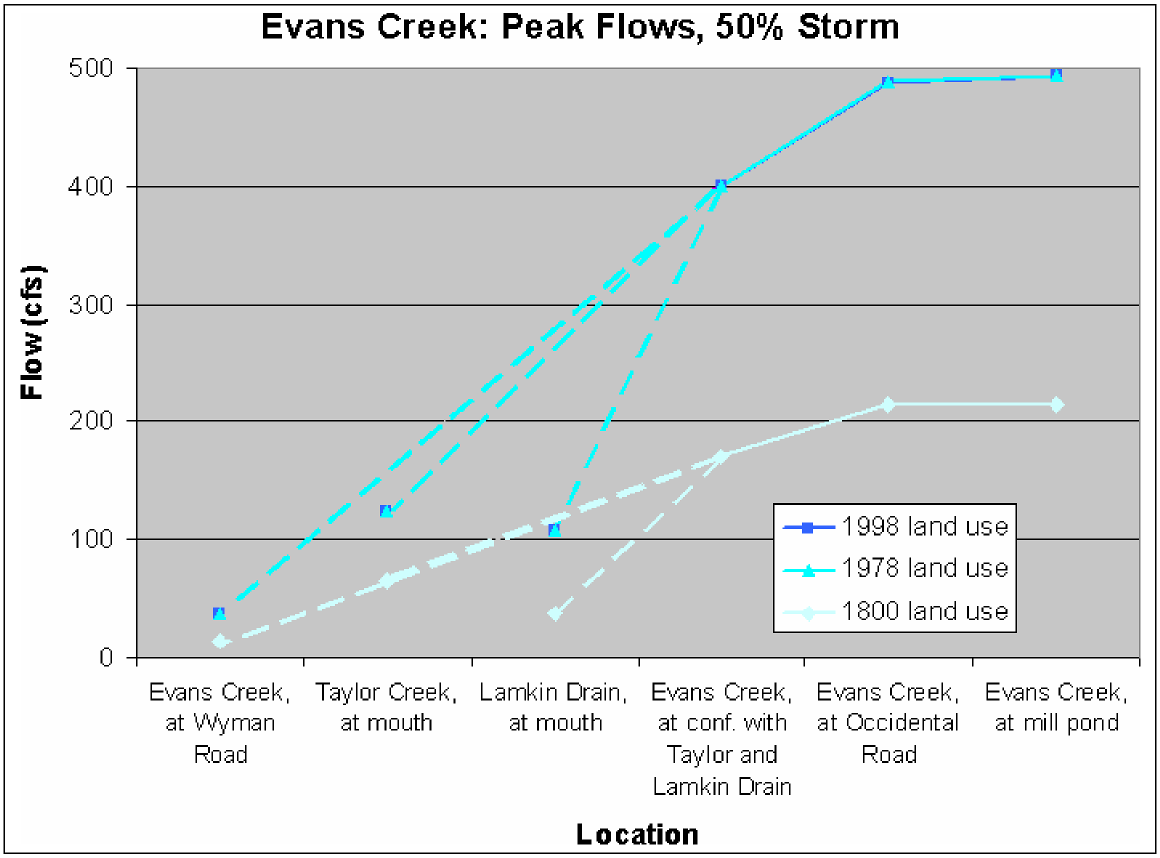

Figure 10: Predicted peak flows for river locations, 50 percent chance storm

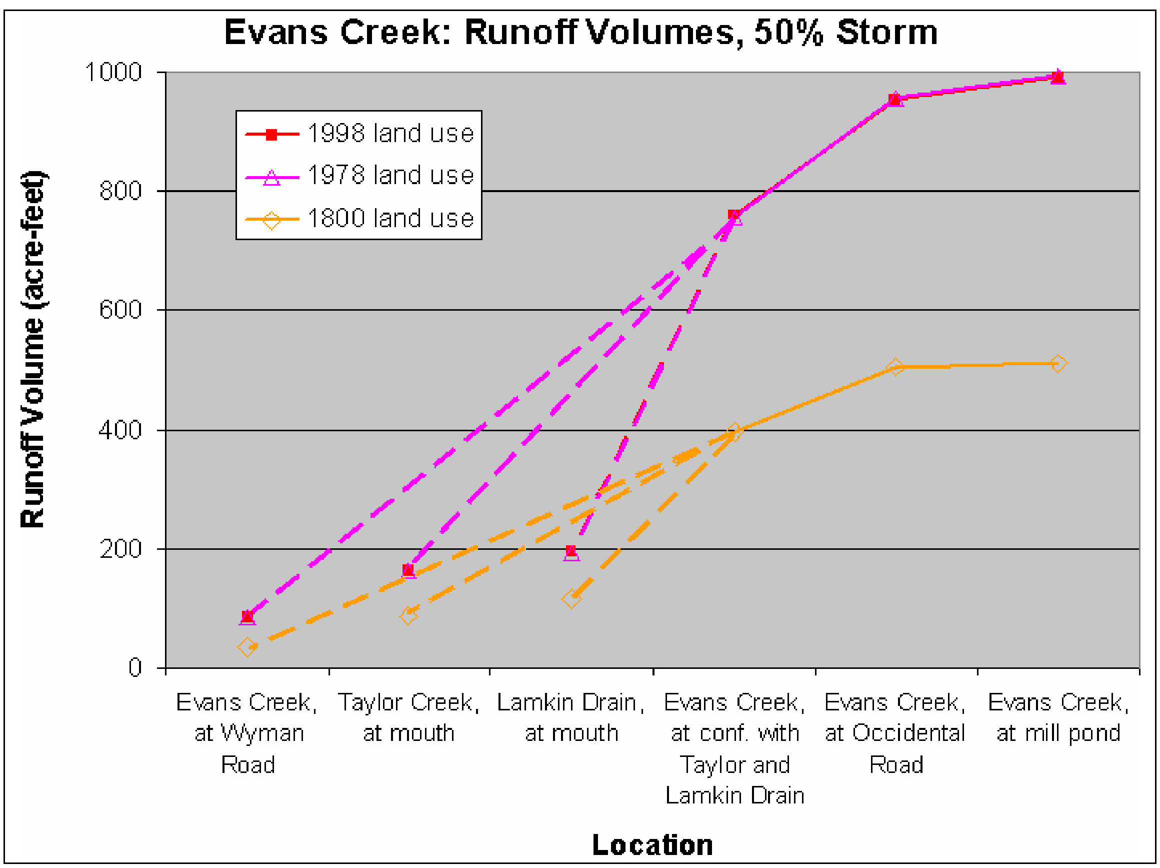

Figure 11: Predicted runoff volumes, 50 percent chance storm

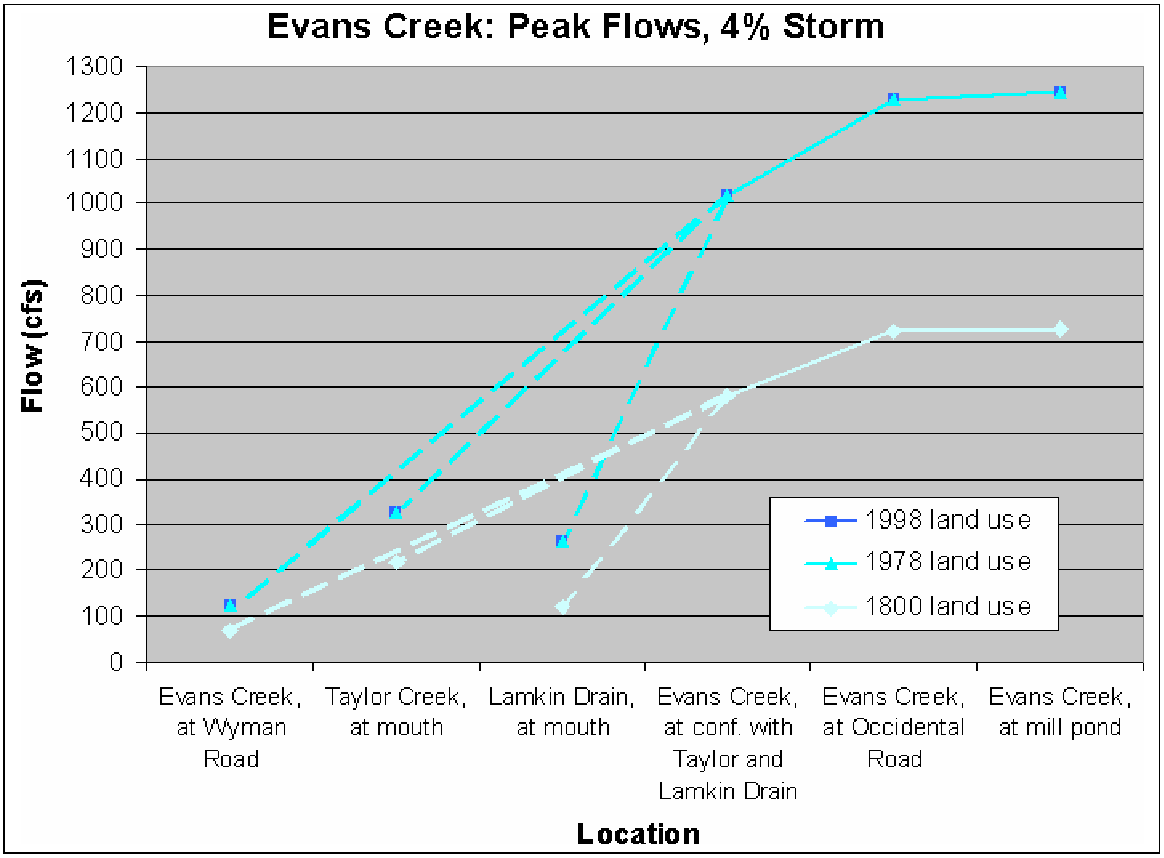

Figure 12: Predicted peak flows for river locations, 4 percent chance storm

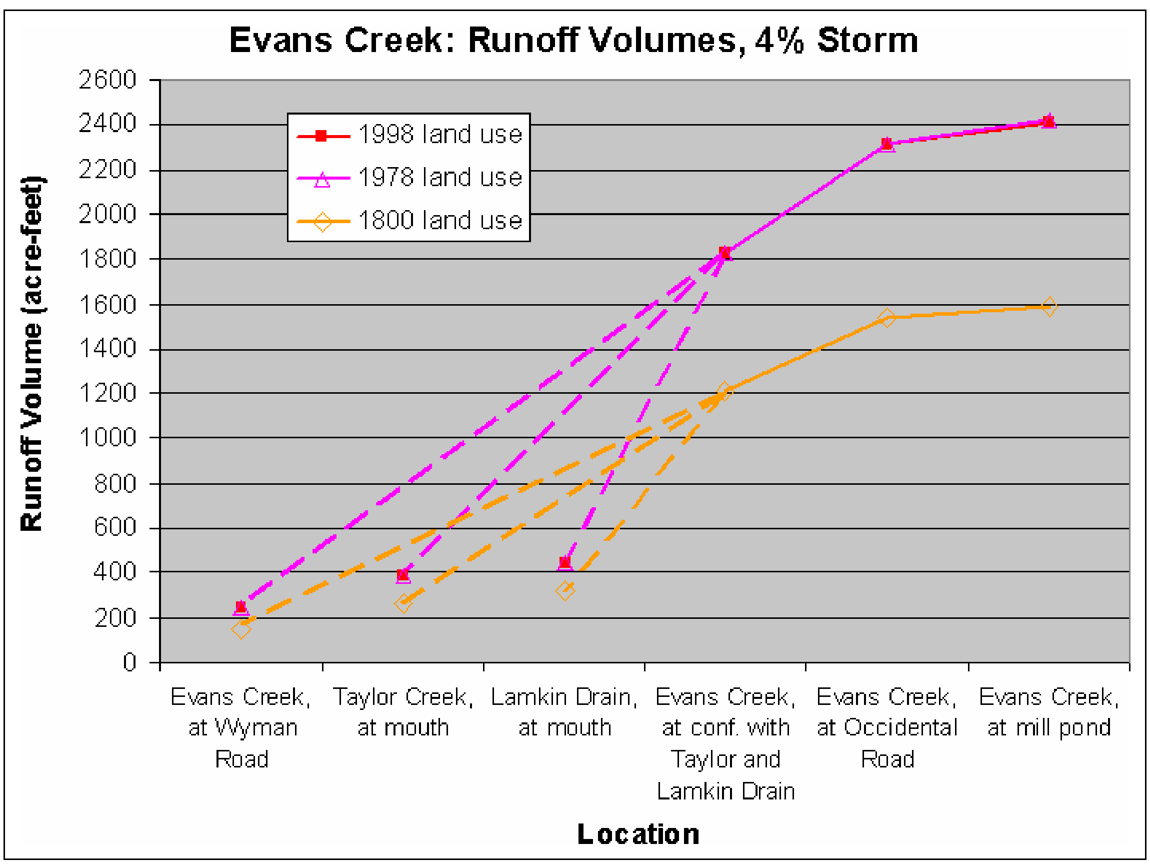

Figure 13: Predicted runoff volumes, 4 percent chance storm

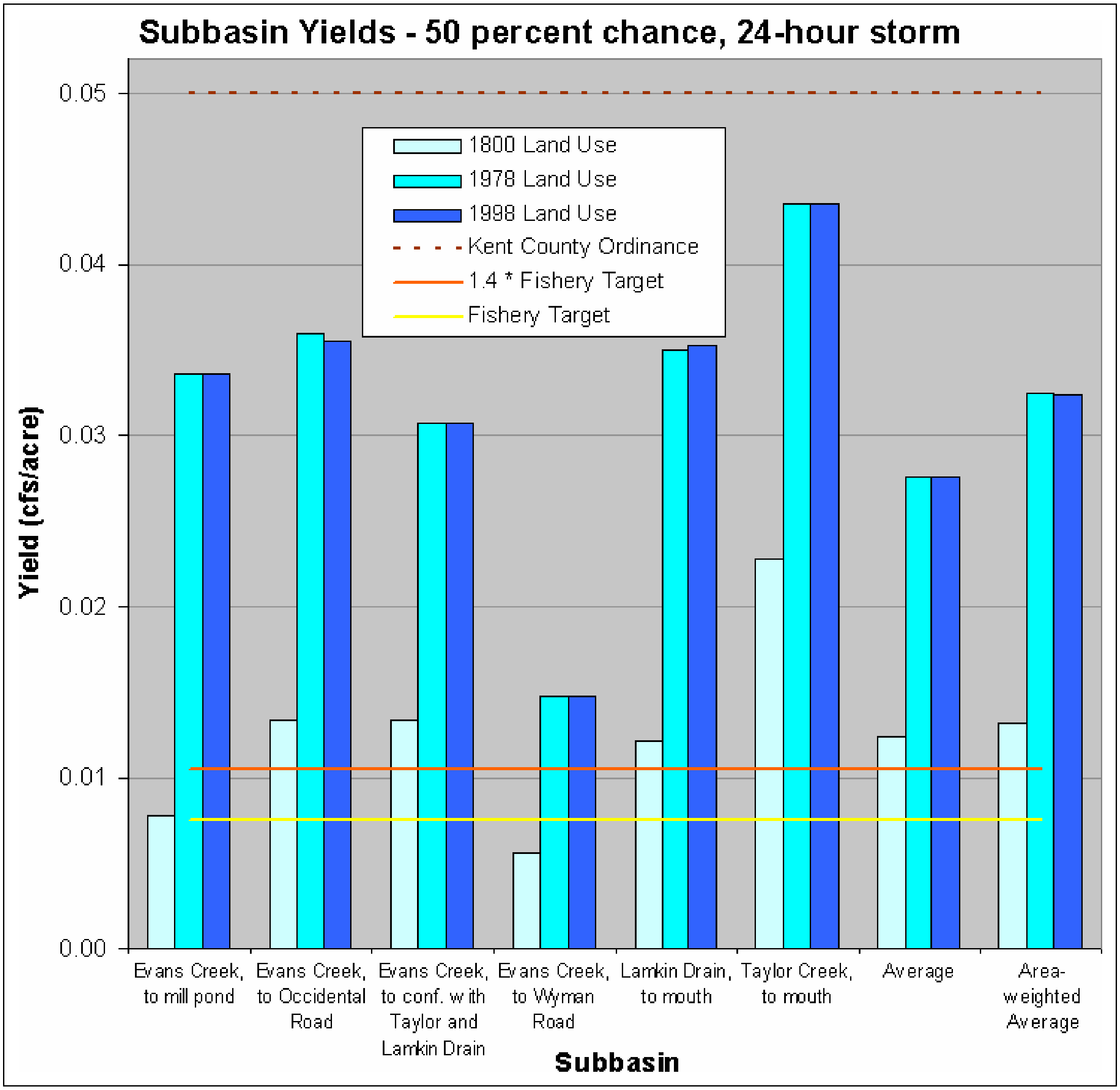

Figure 14: Subbasin Yields, 50 percent chance, 24-hour storm

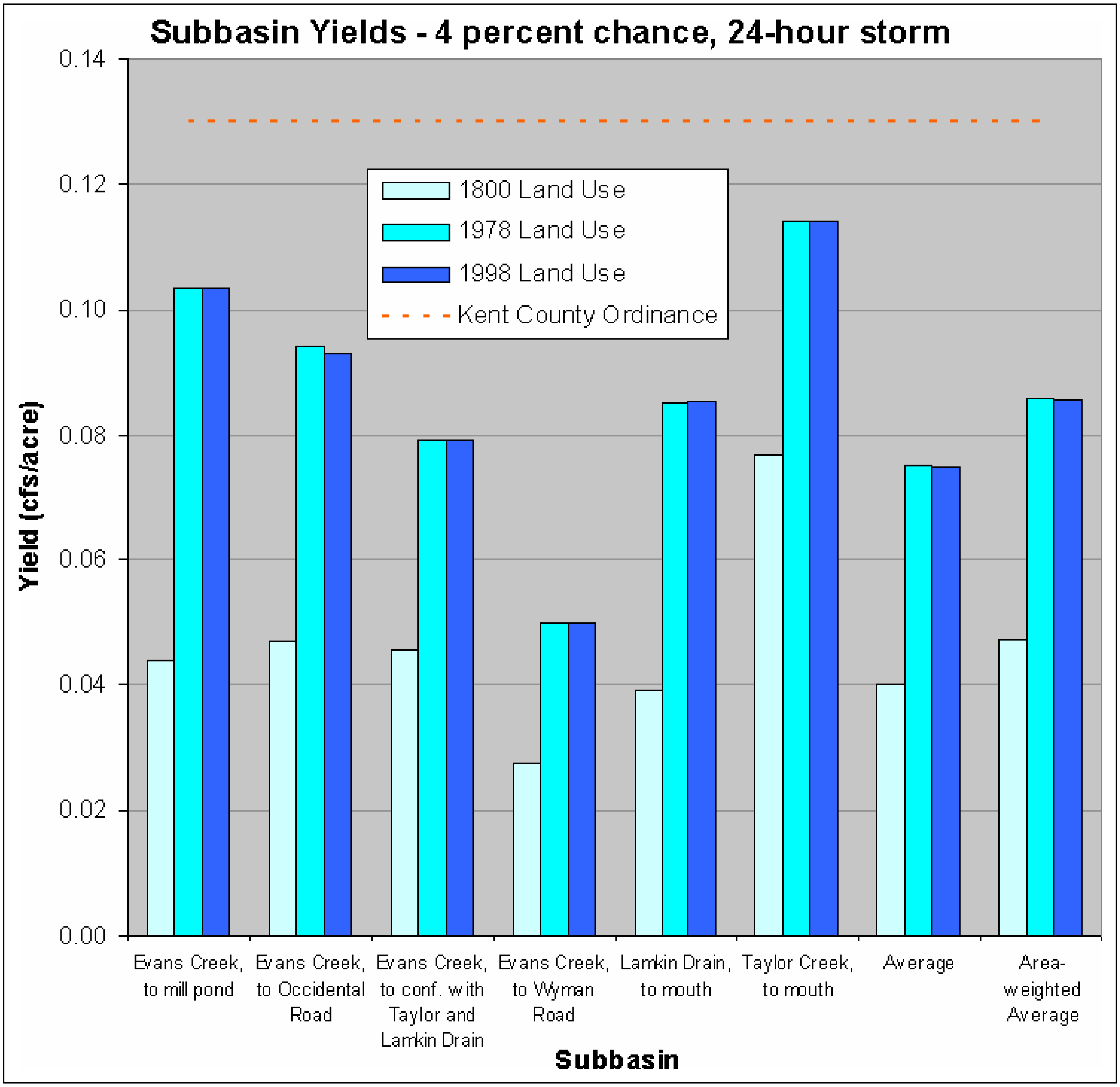

Figure 15: Subbasin Yields, 4 percent chance, 24-hour storm

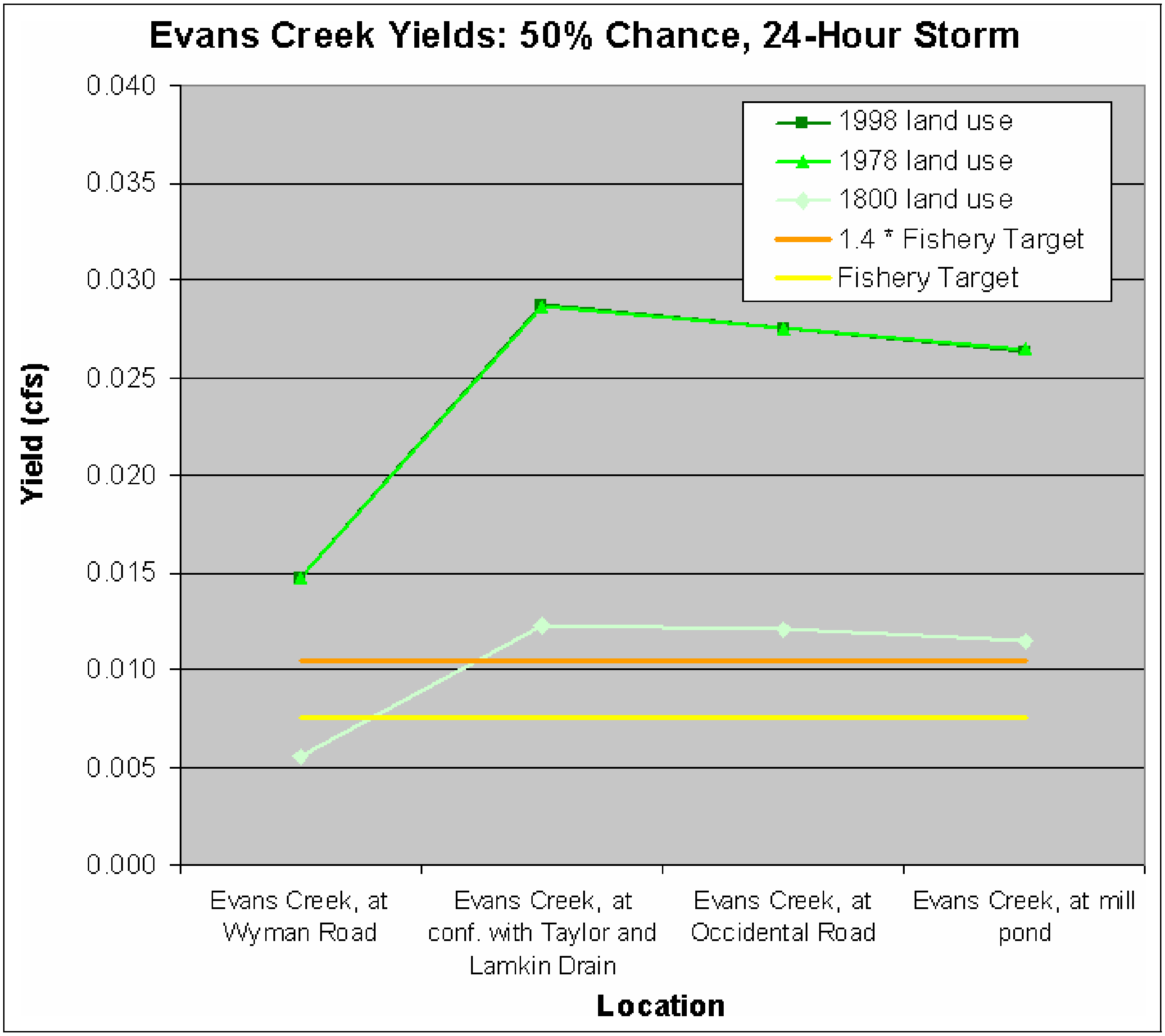

Figure 16: Evans Creek Yields, 50 percent chance, 24-hour storm

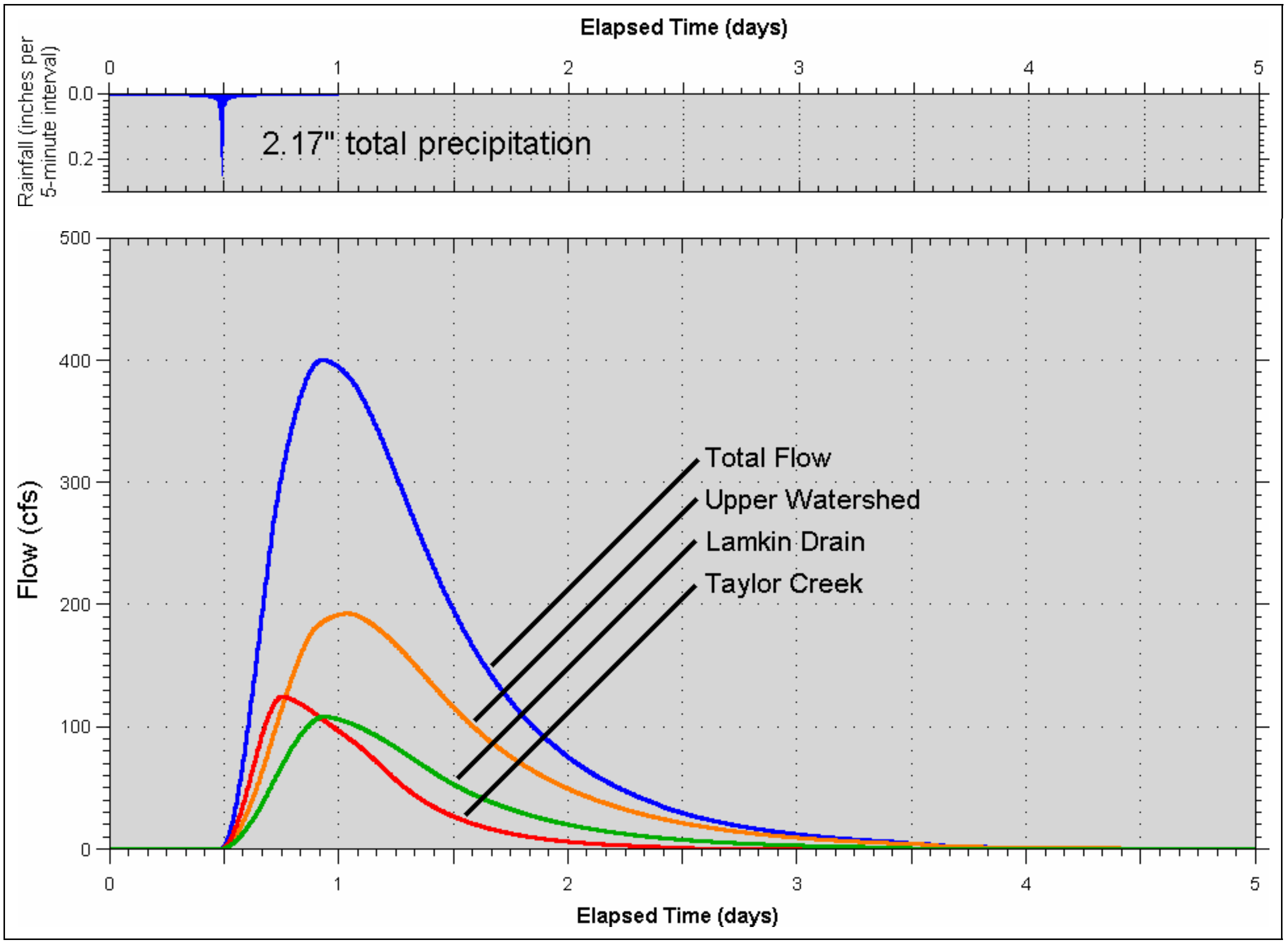

Figure 17: 50 percent chance, 24-hour storm hydrograph for Evans Creek at confluence with Taylor Creek and Lamkin Drain

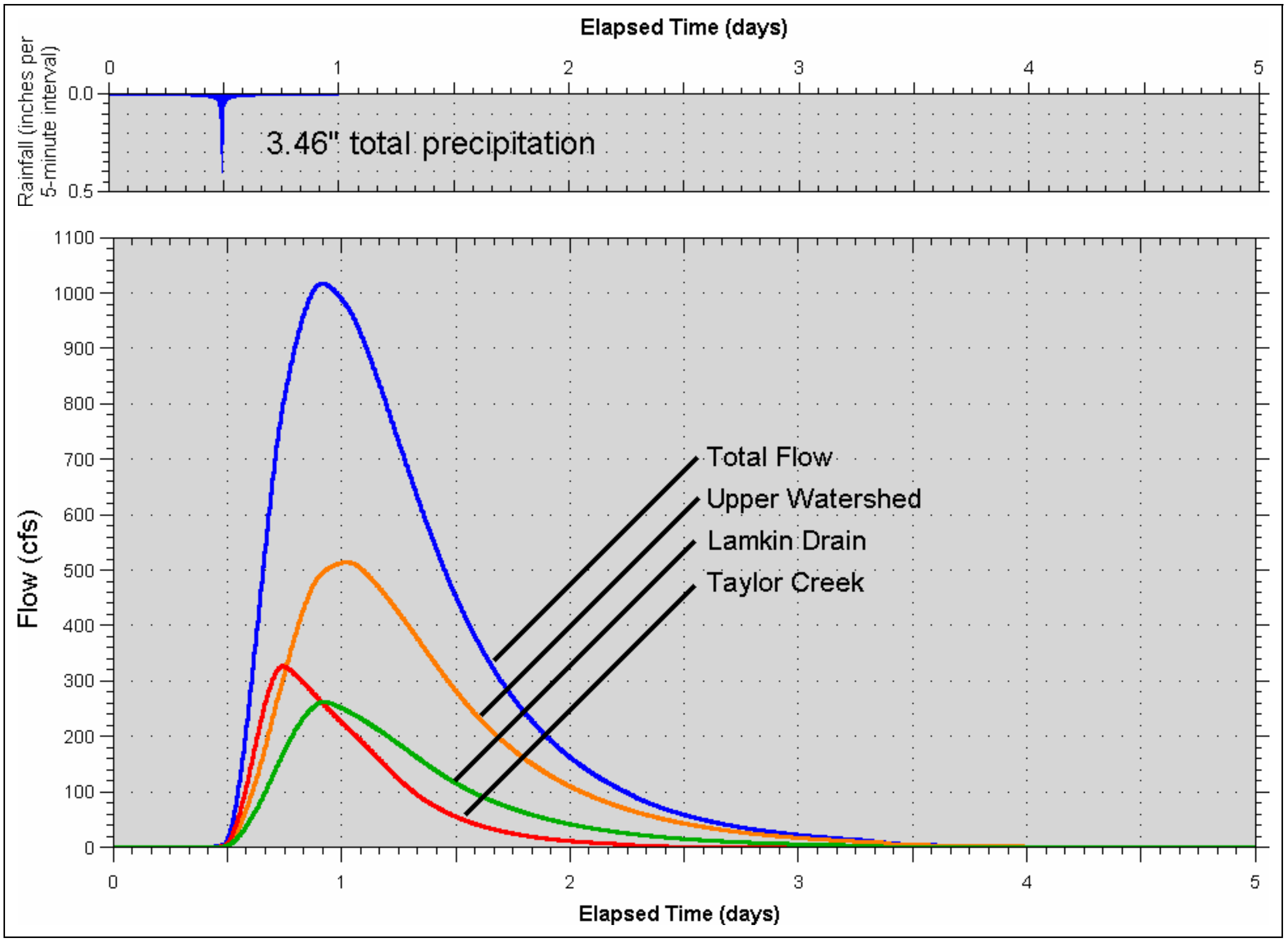

Figure 18: 4 percent chance, 24-hour storm hydrograph for Evans Creek at confluence with Taylor Creek and Lamkin Drain

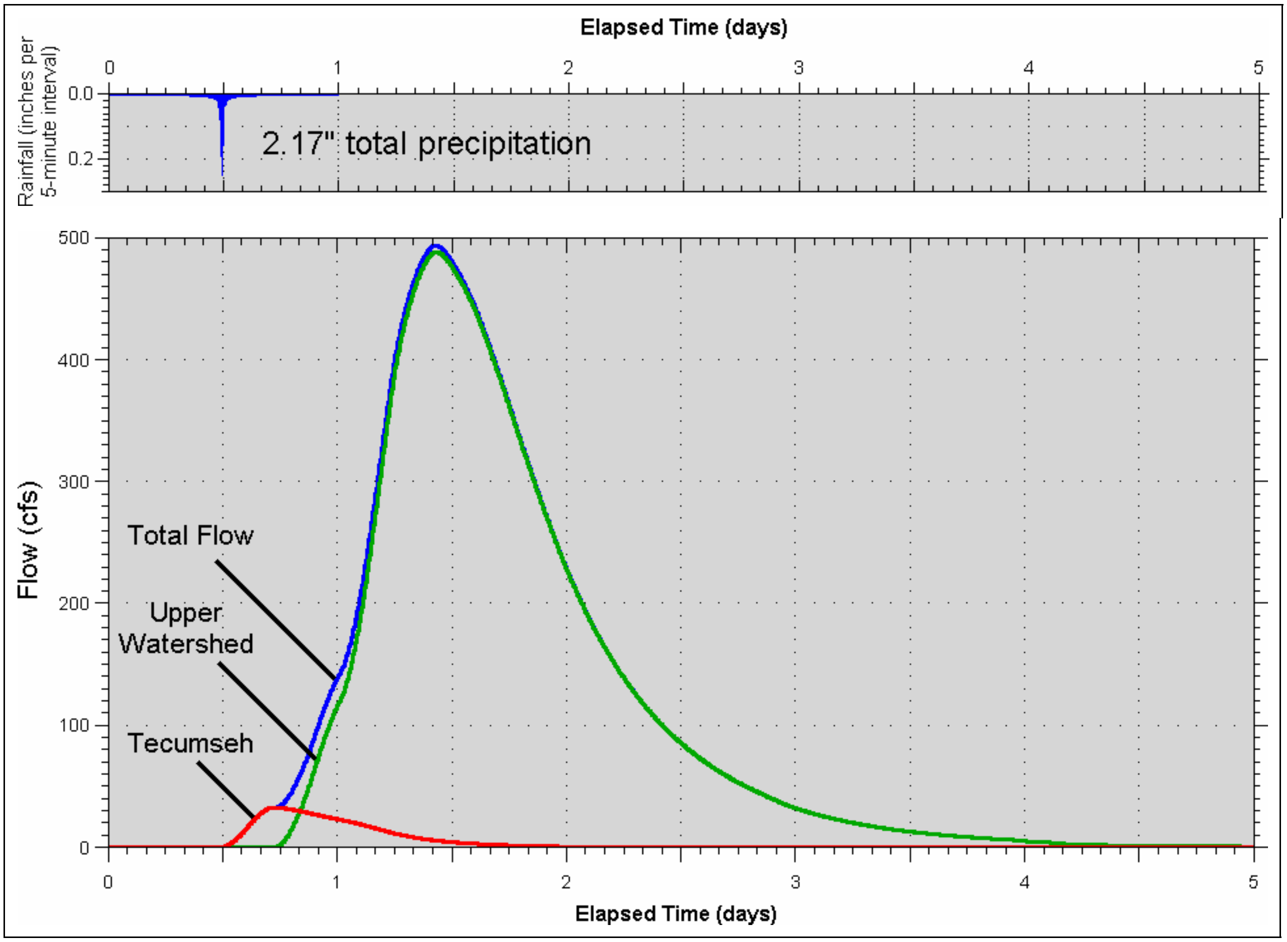

Figure 19: 50 percent chance, 24-hour storm hydrograph for Evans Creek at inlet to Globe Mill Pond

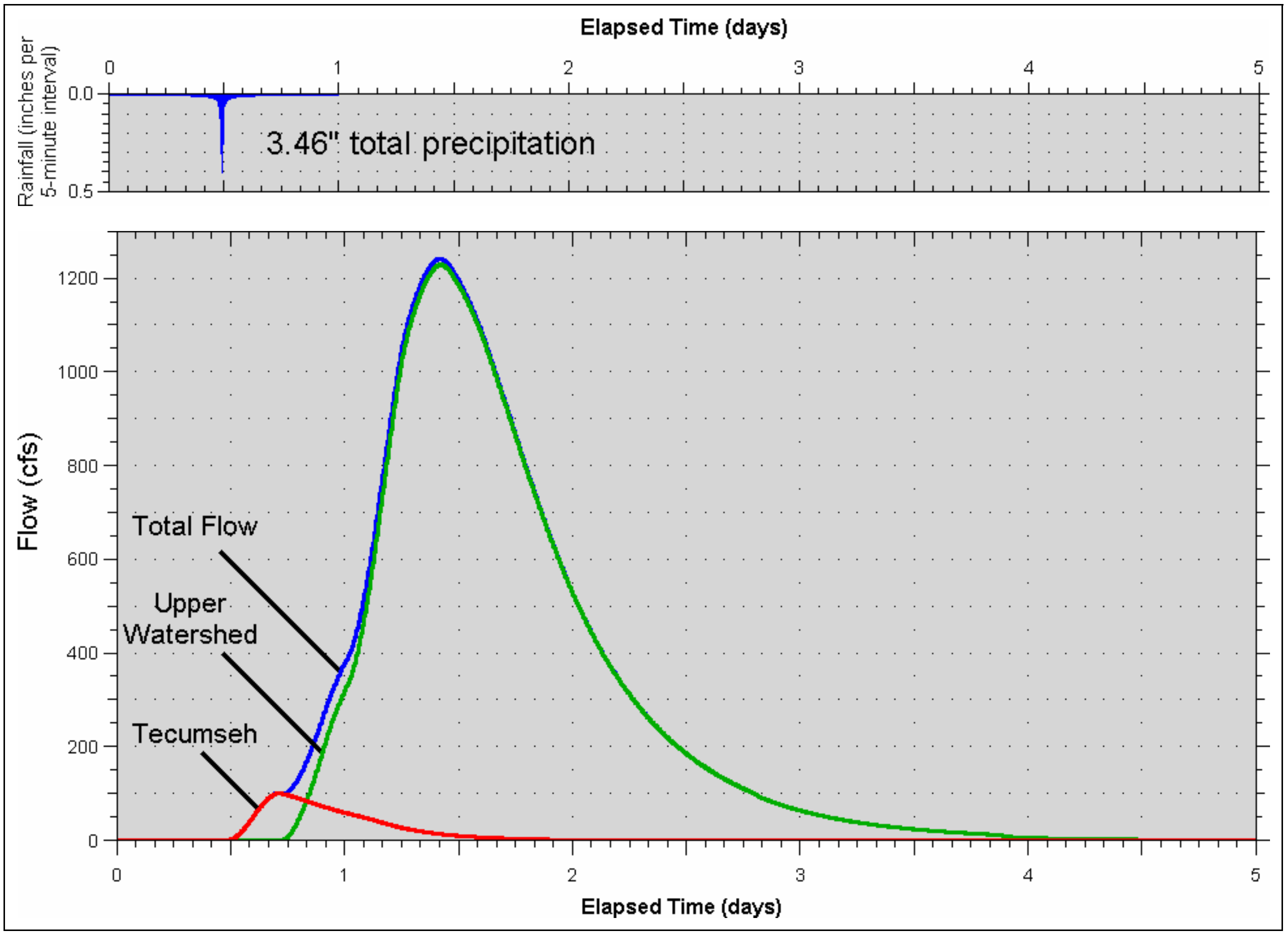

Figure 20: 4 percent chance, 24-hour storm hydrograph for Evans Creek at inlet to Globe Mill Pond

Table 3: Peak flows and runoff volumes per subbasin

Subbasin			Land Use	Peak Flow (cfs)		Yield (cfs/acre)		Runoff Volume (acre-feet)	
ID	Description	Area (sq. mi.)		50%	4%	50%	4%	50%	4%
SEC1	Evans Creek, to Globe mill pond	1.5	1800	8	43	0.008	0.044	9	46
			1978	32	100	0.034	0.103	37	102
			1998	32	100	0.034	0.103	37	102
SEC2	Evans Creek, to Occidental Road	6.0	1800	51	179	0.013	0.047	110	335
			1978	137	359	0.036	0.094	199	488
			1998	135	355	0.035	0.093	196	484
SEC3	Evans Creek, to confluence with Taylor Creek and Lamkin Drain	8.6	1800	73	249	0.013	0.046	156	479
			1978	168	432	0.031	0.079	315	748
			1998	168	432	0.031	0.079	315	748
SEC4	Evans Creek, to Wyman Road	4.0	1800	14	70	0.006	0.028	34	144
			1978	37	127	0.015	0.050	85	245
			1998	37	127	0.015	0.050	85	245
SEC5	Evans Lake	2.8	1800	*	*	*	*	54	163
			1978	*	*	*	*	68	187
			1998	*	*	*	*	69	190
SLD	Lamkin Drain, to mouth	4.8	1800	37	121	0.012	0.039	116	323
			1978	107	261	0.035	0.085	194	446
			1998	108	262	0.035	0.085	195	448
STC	Taylor Creek, to mouth	4.5	1800	65	220	0.023	0.077	88	262
			1978	124	327	0.043	0.114	163	388
			1998	124	327	0.043	0.114	163	388
	Average**		1800			0.012	0.040		
			1978			0.028	0.075		
			1998			0.028	0.075		
	Area Weighted Average**		1800			0.013	0.047		
			1978			0.032	0.086		
			1998			0.032	0.086		

* runoff from this subbasin is expected to accumulate in Evans Lake, raising its water level, and only occasionally resulting in a small discharge to Evans Creek
** does not include Evans Lake subbasin

Table 4: Peak flows and runoff volumes in Evans Creek

River Location			Land Use	Peak Flow (cfs)		Yield (cfs/acre)		Runoff Volume (acre-feet)	
ID	Description	Drainage Area (sq. mi.)		50%	4%	50%	4%	50%	4%
J1	Evans Creek, at mill pond	29	1800	215	726	0.011	0.039	512	1587
			1978	494	1242	0.026	0.066	993	2416
			1998	493	1242	0.026	0.066	991	2414
J2	Evans Creek, at Occidental Road	28	1800	214	721	0.012	0.041	504	1542
			1978	488	1229	0.028	0.069	956	2315
			1998	488	1229	0.027	0.069	955	2312
J3	Evans Creek, at conf. with Taylor Creek and Lamkin Drain	22	1800	172	581	0.012	0.042	395	1208
			1978	399	1016	0.029	0.073	758	1827
			1998	400	1017	0.029	0.073	759	1829
J4	Evans Creek, at Wyman Road	4	1800	14	70	0.006	0.028	34	144
			1978	37	127	0.015	0.050	85	245
			1998	37	127	0.015	0.050	85	245

Appendix: Evans Creek Hydrologic Model Parameters

This appendix is provided so that the model may be recreated. Table A1 provides the design rainfall values specific to the region of the state where Evans Creek is located. Figure A1 summarizes the hydrologic elements in the HEC-HMS model. Tables A2 and A3 provide the parameters that were specified for each of these hydrologic elements. The percent impervious field is left at 0.0, because it is already incorporated in the curve numbers. The initial loss field is left blank so that HEC-HMS uses the default equation based on the curve number. The ponding adjustment factors that were used to adjust the storage coefficients, which represent storage in the subbasin, to provide a peak flow reduction equal to the ponding adjustment factors, are listed in Table A4. Table A5 provides the reach parameters for the lag routing method. HEC-HMS was run for a five-day duration using a five-minute computation interval.

Table A1: Design Rainfall Values

SCS Type II Precipitation Event	Precipitation	Area-adjusted Precipitation*
50% chance (2-year), 24-hour storm	2.26 inches	2.17 inches
4% chance (25-year), 24-hour storm	3.60 inches	3.46 inches

*standard values were multiplied by 0.96 to account for the watershed size

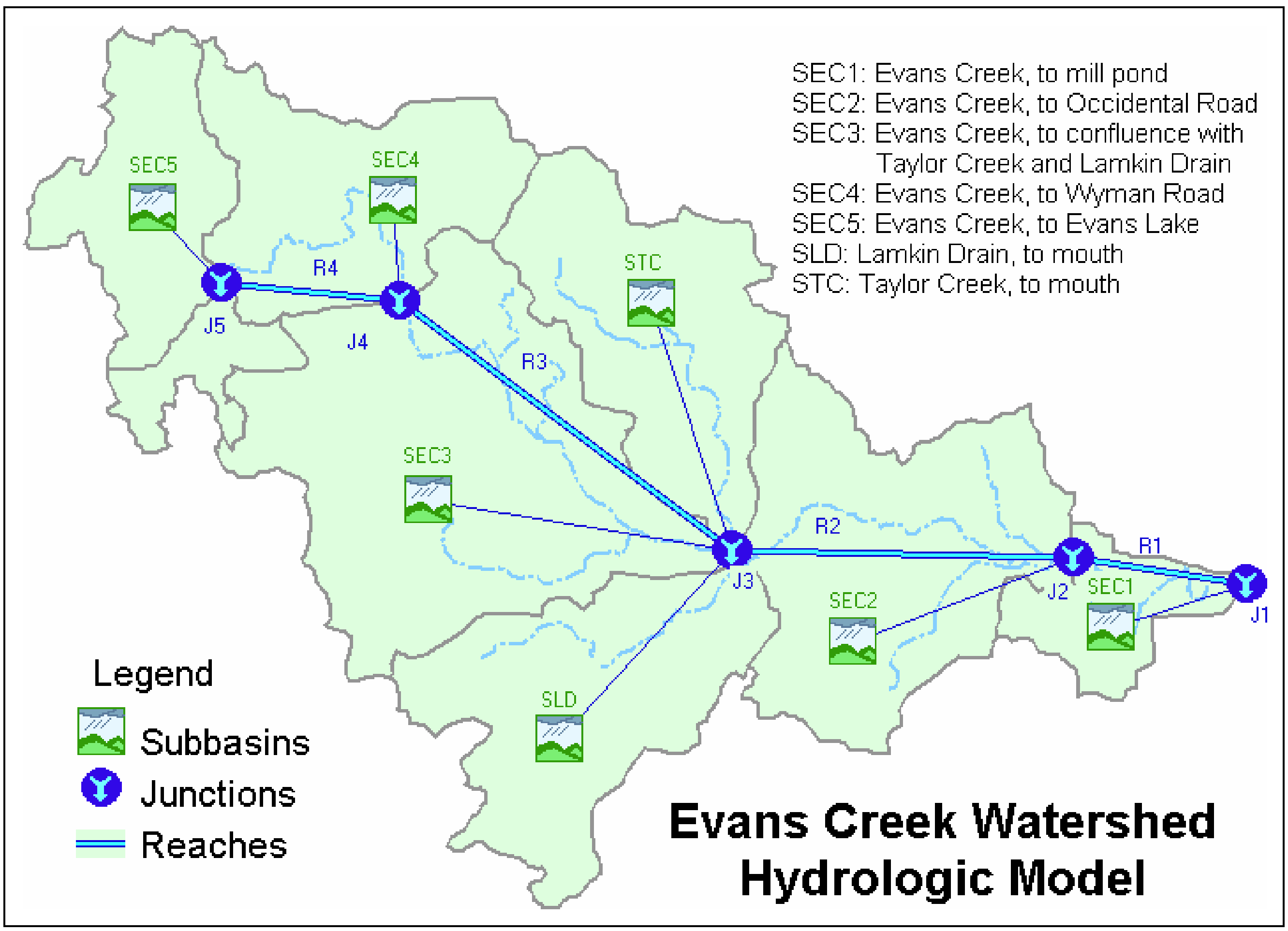

Figure A1: Hydrologic Elements defined for HEC-HMS model

Table A2: Subbasin Parameters – Area and Curve Number

Subbasins		Drainage Area (sq. mi.)	Runoff Curve Number		
ID	Description		1800	1978	1998
SEC1	Evans Creek, to mill pond	1.51	61.4	74.8	74.8
SEC2	Evans Creek, to Occidental Road	5.96	71.3	79.0	78.8
SEC3	Evans Creek, to conf. with Taylor and Lamkin Drain	8.55	71.2	80.5	80.5
SEC4	Evans Creek, to Wyman Road	3.95	64.0	73.2	73.2
SEC5	Evans Lake	2.82	71.8	74.5	74.8
SLD	Lamkin Drain, to mouth	4.80	74.9	81.9	82.0
STC	Taylor Creek, to mouth	4.47	72.1	80.3	80.3
NC	non-contributing	1.08			
	Total	33.15			

Table A3: Subbasin Parameters – Times of Concentration and Storage Coefficients

Subbasin ID	Land Use Scenario	Time of Concentration (hours)	Storage Coefficient	
			50% chance, 24-hour storm	4% chance, 24-hour storm
SEC1	1800	5.19	5.19	5.19
	1978		6.07	5.78
	1998		6.07	5.78
SEC2	1800	8.16	15.60	13.08
	1978		8.85	8.57
	1998		8.85	8.57
SEC3	1800	9.55	15.27	13.40
	1978		13.04	12.09
	1998		13.04	12.10
SEC4	1800	7.84	19.48	14.63
	1978		17.06	13.93
	1998		17.07	13.93
SEC5	1800	4.59	14.57	10.60
	1978		12.66	9.85
	1998		12.68	9.88
SLD	1800	10.44	27.16	21.73
	1978		12.30	11.71
	1998		12.30	11.71
STC	1800	5.98	7.51	7.03
	1978		8.02	7.49
	1998		8.02	7.48

Table A4: Ponding Adjustment Factors

1800 Ponding Adjustment				
Subbasin	Percent Ponding within Subbasin	Location of Ponding within Subbasin	50% Storm Adjustment Factor	4% Storm Adjustment Factor
SEC1	0.0%		1.00	1.00
SEC2	4.2%	Throughout/middle	0.67	0.73
SEC3	2.3%	Throughout/middle	0.75	0.80
SEC4	8.4%	Throughout/middle	0.60	0.67
SLD	20.2%	Throughout/middle	0.53	0.60
STC	0.6%	Throughout/middle	0.87	0.90
1978 Ponding Adjustment				
Subbasin	Percent Ponding within Subbasin	Location of Ponding within Subbasin	50% Storm Adjustment Factor	4% Storm Adjustment Factor
SEC1	0.9%	Upper	0.91	0.93
SEC2	0.3%	Upper	0.95	0.97
SEC3	1.3%	Throughout/middle	0.82	0.86
SEC4	7.8%	Throughout/middle	0.61	0.68
SLD	0.4%	Throughout/middle	0.90	0.93
STC	1.1%	Throughout/middle	0.83	0.87
1998 Ponding Adjustment				
Subbasin	Percent Ponding within Subbasin	Location of Ponding within Subbasin	50% Storm Adjustment Factor	4% Storm Adjustment Factor
SEC1	0.9%	Upper	0.91	0.93
SEC2	0.3%	Upper	0.95	0.97
SEC3	1.3%	Throughout/middle	0.82	0.86
SEC4	7.8%	Throughout/middle	0.61	0.68
SLD	0.4%	Throughout/middle	0.90	0.93
STC	1.1%	Throughout/middle	0.83	0.87

Table A5: Channel Reach Parameters

ID	Reach	Lag (minutes)
R1	Evans Creek, to mill pond	347
R2	Evans Creek, to Occidental Road	420
R3	Evans Creek, to confluence with Taylor Creek and Lamkin Drain	354
R4	Evans Creek, to Wyman Road	323